

NON-PROVISIONAL APPLICATION FOR UNITED STATES PATENT

FOR

**AUTOMATIC SHUT OFF OF BACKUP POWER SOURCE
IN THE EXTENDED ABSENCE OF AC POWER**

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Attorney Docket No.: 110349-133957
IPG No: P17356

Express Mail Label No. EL782197014US
Filing Date: August 19, 2003

BACKGROUND

Advances in integrated circuits and microprocessor technologies have
5 made possible the availability of computing devices, such as personal
computers, with computing power that was once reserved for "main frames". As
a result, increasingly computing devices, such as personal computers, are being
used for a wide array of computations, and often, "important" computations.

However, computing devices, such as personal computers, are still being
10 provided without integral backup power support. Further, unlike their server
brethrens, typically, supplemental external backup power supports are seldom
employed. Thus, whenever the power supply fails, these computing devices go
into an un-powered state, and the system states are lost.

For those computing devices endowed with power management
15 implemented in accordance with the Advanced Configuration and Power
Interface (ACPI) (jointly developed by Hewlett Packard, Intel, et al), the
computing devices are said to be in the "un-powered" G3 state.

Moreover, when power is restored, and a user presses the power button
of the computing device, the user typically gets a number of messages from the
20 operating system (OS) of the computing device. Unfortunately, many of these
messages are understood by sophisticated users only. Examples of these
messages include asking the user whether the user desires to boot the
computing device into a safe mode, have the disk drive scanned, and so forth.

If acceptance of computing devices, such as personal computers, is to
25 continue to expand, and the computing devices are to be used by more and more
users for an increasing variety of applications, such as "entertainment"
applications, it is necessary for their usability, availability, and/or reliability to

continue to improve. Further, it is necessary for the usability, availability, and/or reliability to be improved cost effectively.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will be described by way of the accompanying drawings in which like references denote similar elements, and in
5 which:

Figure 1 illustrates an overview of a system incorporated with the teachings of embodiments of the present invention, including a power supply having a backup power source and an arrangement to shut off the backup power source after drawing on the backup power source for a period of time;

10 **Figure 2a** illustrates the operational states of the system of **Fig. 1**, in accordance with one embodiment;

Figure 2b illustrates embodiments of the power supply of **Fig. 1** in further details, including an interface to shut off the backup power source;

15 **Figure 2c** illustrates an example article having programming instructions implementing all or the relevant portions of the BIOS of **Fig. 1** to shut off the backup power source, in accordance with one embodiment;

Figure 3 illustrates embodiments of the relevant operation flow of the system to suspend the system to memory in responding to an AC failure condition, while operating in an active state, including the BIOS intervening to set
20 up the system to shut off the backup power source after a period of time, and;

Figure 4 illustrates embodiments of the relevant operation flow of the system to resume the system to an active state in responding to an AC re-presence condition, while operating in a suspended state, including the BIOS canceling previous set up to shut off the backup power source at a later time; and

25 **Figures 5a-5b** illustrate embodiments of the relevant operation flow of the system in shutting off the backup power source.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Embodiments of the present invention include but are not limited to
5 method for shutting DC power source off, BIOS and/or chipset equipped to
facilitate practice of the method, power supply with DC power source that may be
shut off, and components, circuit boards or devices endowed with the BIOS,
chipset and/or power supply.

In the following description, various aspects of embodiments of the
10 present invention will be described. However, it will be apparent to those skilled
in the art that other embodiments may be practiced with only some or all of the
described aspects. For purposes of explanation, specific numbers, materials and
configurations are set forth in order to provide a thorough understanding of the
embodiments. However, it will be apparent to one skilled in the art that other
15 embodiments may be practiced without the specific details. In other instances,
well-known features are omitted or simplified in order not to obscure the
description.

Various operations will be described as multiple discrete operations in
turn, in a manner that is most helpful in understanding the embodiments,
20 however, the order of description should not be construed as to imply that these
operations are necessarily order dependent. In particular, these operations need
not be performed in the order of presentation.

The phrase "in one embodiment" is used repeatedly. The phrase
generally does not refer to the same embodiment, however, it may. The terms
25 "comprising", "having" and "including" are synonymous, unless the context
dictates otherwise.

Referring now to **Fig. 1** wherein an overview of a system incorporated with the teachings of one embodiment of the present invention is illustrated. For the embodiment, system **100** includes processor **102**, non-volatile memory **104**,
5 memory **106**, controller/bus bridge **108**, persistent storage **110**, other I/O devices **112**, buses **114a-114b**, and power supply **116**, coupled to each other as shown. Controller/bus bridge **108** is also referred to as memory and I/O controller/bus bridge (MCH/ICH/BB) **108**.

Non-volatile memory **104** includes in particular basic input/output system
10 (BIOS) **124** incorporated with the teachings of one embodiment of the present invention. Memory **106** includes a working copy of operating system (OS) **126** and system state data **128a**. The term "system state" as used herein includes OS and application states and data. MCH/ICH/BB **108** is equipped to interrupt processor **102**, when system **100** is in an active state and an AC failed or absent
15 condition arises. More specifically, for the embodiment, the interrupt is issued by the ICH portion of MCH/ICH/BB **108**. MCH/ICH/BB **108** is further equipped to facilitate OS **126** to cause system **100** to go into the "suspended to memory" state. Further, MCH/ICH/BB **108** is equipped to shut off delivery of "normal" power (leaving only standby power) to cause system **100** to go into a "suspended
20 to memory" state. MCH/ICH/BB **108** is also equipped to process device wake events, including a notification of AC re-presence while system **100** is in a suspended to memory state. In particular, MCH/ICH/BB **108** is equipped to allow resumption of delivery of "normal" power, initiate waking of system **100**, and facilitate BIOS to initiate a resume process. Similarly, for the embodiment,
25 processing of device wake events is performed at the ICH portion MCH/ICH/BB **108**. [AC = Alternating Current.]

Power supply **116** includes integral backup DC power source **132**, to source power for system **100** while system **100** is in an AC failed or absent condition, and a monitor **130** equipped to signal **136** presence or absence of AC power at power supply **116**. An example of integral backup DC power source **132** is a battery. For the purpose of present application, the terms "AC failed" or "AC absence" should be considered synonymous, unless the context clearly indicates to the contrary. Hereinafter, integral backup DC power source **132** may also be simply referred to as either backup power source or DC power source. Further, in alternate embodiments backup power source may be a non-DC power source. [DC = Direct Current.]

Integral DC power source **132** includes in particular a switch (not shown) and interface to shut off integral DC power source **132** from sourcing power for system **100**, especially after integral DC power **132** has been sourcing power for system **100** for a "prolonged" period of time, during absence of AC. Of course, what constitutes a "prolonged" period of time may be dependent on a number of factor, including but are not limited to the capacity of DC power source **132** and the "typical" draw rate on DC power source **132** during absence of AC.

Preferably, the period of time, after passing of which the DC power source **132** should be shut off, is specifiable to system **100**. Such specification may be made in any one of a number of operational parameter specification manners.

Still referring to **Fig.1**, MCH/ICH/BB **108** includes in particular real time clock **144** which may be employed to initiate waking of system **100** after the period of time, to facilitate shutting off of integral DC source of power **132** from sourcing power for system **100**.

For the embodiment, MCH/ICH/BB **108** further includes a timer **146** and companion logic (not shown) to facilitate shutting off of integral DC source of power **132** from sourcing power for system **100** instead. In alternate

embodiments, the timer and companion logic may be disposed in power supply **116** or other hardware element instead.

Resultantly, system **100** is prevented from drawing on the integral DC source of power **132** for an undesirable extended period of time. Accordingly,
5 the capacity of integral DC source of power may be smaller, and less costly. Thus, system **100** may be provided with integral backup power, more specifically, integral DC backup power **132** in a more cost effective manner.

Further, when coupled with the ability to preserve an operational state of system **100** when it suspends to memory, the ability to deterministically shut off
10 DC power source **132** enables system **100** to be more readily returned to a last known system state, according the user possibly a better usability experience.

Still referring to **Fig. 1**, except for teachings of embodiments of the present invention incorporated, processor **102**, non-volatile memory **104**, memory **106**, MCH/ICH/BB **108**, persistent storage **110**, I/O devices **112**, and buses **114a-**
15 **114b** all represent corresponding broad ranges of these elements. In particular, an example of an I/O device is a networking interface. Similarly, except for the teachings of present invention, BIOS **124** and OS **126** also represent corresponding broad ranges of the elements. In various embodiments, MCH/ICH/BB **108** and/or other elements are packaged in the form of chipsets.

20 Various embodiments of these teachings incorporated in MCH/ICH/BB **108**, power supply **116**, BIOS **124**, the operational states and various operational flows of system **100** will be described in turn below.

In various embodiments, system **100** may be a desktop computer, a set-top box, an entertainment control console, a video recorder, or a video player.

25 Further, alternate embodiments may be practiced without some of the enumerated elements or with other elements. In particular, alternate embodiments may be practiced without DC power source **132** being an integral

part of system **100**. That is, for these embodiments, DC power is provided from a source external to system **100**.

Figure 2a illustrates one embodiment of the operational states of system **100**. For ease of understanding, the operational states will be described assuming system **100** also includes implementation of ACPI, and mapped to the ACPI states. For the embodiment, the operational states of system **100** include three major operational states, active state (ACPI S0 or simply, S0) **202**, suspended state (ACPI S3 or simply, S3) **204** and un-powered state (ACPI G3 or simply G3) **206**. However, alternate embodiments may be practiced without mapping to ACPI states or implementation of ACPI. For further information on ACPI including ACPI states, see The ACPI Specification, Revision 2.0b.

Within active state (S0) **202**, system **100** may be in “visual on” state **212**, or “visual off” state **214**. While system **100** is in “visual on” state **212**, user perceptible indications of system activity may be selectively activated as appropriate, including but are not limited to display devices, light emitting diodes (LEDs), speakers, and so forth. On the other end, while system **100** is in “visual off” state **214**, all visual and aural elements of system **100** are “off”, giving a user the impression that system **100** has been “turned off”. As illustrated, system **100** may transition between “visual on” state **212** and “visual off” state **214** based at least in part on power button (PB) events **222**.

Having visual “on” and “off” states **212** and **214** within active state (S0) **202** is a non-essential aspect of the disclosed embodiments of the present invention. The feature is the subject matter of co-pending U.S. Patent Application, number <to be inserted>, entitled <insert title>, and filed on mm/dd/yy. For further details, see the co-pending application.

Still referring to **Fig. 2a**, for the embodiment, within suspended state (S3) **204**, system **100** may be in “suspended to memory” state **216** or “suspended to memory with a persistent copy of the system state saved” state **218**. System **100** may enter into “suspended to memory” state **216** from either “visual on” state **202** or “visual off” state **204**, due to e.g. “inactivity”, user instruction, or an “AC failure” condition, **224** and **226**. System **100** is considered to be in the “AC failure” condition, whenever AC is not present at power supply **116**.

Additionally, for the embodiment, as part of the entry into the “suspended to memory” state **216**, a persistent copy of the then system state is saved, resulting in system **100** automatically transitions from “suspended to memory” state **216** to “suspended to memory with a persistent copy of the system state saved” state **218**.

Automatic saving of a persistent copy of the then system state is also not an essential aspect of the disclosed embodiments of the present invention. The feature is the subject matter of co-pending U.S. Patent Application, number <to be inserted>, entitled “Operational State Preservation in the Absence of AC Power”, and filed contemporaneously. For further details, see the co-pending application.

From “suspended to memory with a persistent copy of the system state saved” state **218**, system **100** enters un-powered state (G3) **206** if the integral DC power source is shut off or exhausted **230**. The feature of shutting off the DC power source off to prevent it from being exhausted will be further described below.

From “suspended to memory with a persistent copy of system state saved” state **218**, system **100** may transition back to either “visual on” state **212** or “visual off” state **214** in response to AC re-presence, or a power button/device wake event **232/234** if AC is present (state **218** entered due to inactivity). In

various embodiments, the latter transitions are permitted only if AC is present at power supply **116**, else the power button or device wake events are suppressed or ignored.

Suppressing or ignoring power button and device wake events when AC is
5 absent, is also not an essential aspect of the disclosed embodiments of the present invention. The feature is the subject matter of co-pending U.S. Patent Application, number <to be inserted>, entitled "Power button and Device wake events Processing Methods in the Absence of AC Power", and filed contemporaneously.

10 Further, system **100** returns to "visual off" state **214** if AC becomes present again while system **100** is in "un-powered" state (G3) **206**.

Referring now to **Fig. 2b**, wherein one embodiment of power supply **116** is illustrated. As shown, for the embodiment, power supply **116** includes integral
15 backup DC power source **132**, monitor **130** and switch **246**, as described earlier. Additionally, for the embodiment, power supply **116** includes multiple power outputs (also referred to as power rail) **244**. The elements are coupled to each other as shown.

For the embodiment, switch **246** is coupled to timer **146** and its companion
20 logic **148** of MCH/ICH/BB **108** as shown. Thus, it can be seen, in alternate embodiments, timer **146** and companion logic **148** may be disposed in power supply **116** instead.

Accordingly, power outputs **244** may continue to supply power to elements of system **100**, drawing on integral DC power source **132**, in the absence of AC
25 at power supply **116**. However, the sourcing of power by DC power supply **132** may be shut off by turning off switch **246**, preventing DC power supply **132** from being exhausted, especially during prolonged absence of AC.

Further, monitor **130** is able to output a signal denoting whether AC is present or absent at power supply **116** at any point in time.

Additionally, timer **146** may be employed to generate a timing signal denoting expiration of the period of time, beyond which DC power source **132** should not be drawn on. Companion logic **148** enables one or more additional factors to be taken into consideration before actually generating the shut off signal. An example of such factors is whether AC has returned.

In various embodiments, the additional qualification of the generation of the shut off signal may not have to be practiced. For example, DC power source **132** is either explicitly or implicitly shut off on presence of AC, and further shutting it off would not cause the source of power to be “flipped” to DC power source **132**, rendering the consideration unnecessary. Further, BIOS **124** may be equipped to cancel a setting of timer **146**, when it resumes system **100** into an active state on return of AC power, thus ensuring expiration of timer **146** occurs only in the context of absence of AC.

In various embodiments, DC power source **132** may be a battery. Monitor **130** may be implemented employing a diode and RC coupled to a comparator to provide signal **136**. Further, a logical “1” of signal **136** denotes AC present at power supply **116**, whereas a logical “0” of signal **136** denotes AC absent at power supply **116**.

In various embodiments, power outputs **244** may include normal and standby power outputs. Normal power outputs may include +12v, +5v, +3v, and -12v, whereas standby power output may include +5v. Further, the normal power outputs may be turned off.

25

Figure 2c illustrates an example article having programming instructions implementing all or the relevant portions of BIOS **124** of **Fig. 1**, in accordance

with one embodiment. As illustrated, article **250** includes a storage medium **252** and programming instructions **252** implementing all or the relevant portions of BIOS **124** of **Fig. 1**. As alluded to earlier and to be described in more detail below, BIOS **124** includes teachings of at least one embodiment of the present invention to facilitate shutting off DC power source **132**.

For the embodiment, article **250** may be a diskette. In alternate embodiments, article **250** may be a compact disk (CD), a digital versatile disk (DVD), a tape, a compact Flash, or other removable storage device of the like, as well as a mass storage device, such as a hard disk drive, accessible for downloading all or the relevant portions of BIOS **124** via e.g. a networking connection.

Figure 3 illustrates one embodiment of the relevant operation flow of system **100** to suspend system **100** to memory in responding to an AC failure condition, while operating in active state **202**, including BIOS **124** setting up system **100** to shut off DC power source after sourcing power for system **100** for a period of time.

As illustrated, while operating in active state **202**, power supply **116** monitors for AC presence or absence, and outputs a signal to denote AC presence or absence accordingly, block **302**. In alternate embodiments, the monitoring and signaling of AC presence or absence at power supply **116** may be performed by another element other than power supply **116**. Regardless, the monitoring and signaling continues as long as AC is present at power supply **116**.

However, when AC fails or absent from power supply **116**, and monitor **130** outputs a signal so denoting, for the embodiment, MCH/ICH/BB **108** asserts

an interrupt, block **304**, notifying processor **102** to switch execution to a portion of OS **126** (interrupt handler) to place system **100** in a suspended state, block **306**.

In various embodiments, the suspend process involves OS **126** writing to a special register of MCH/ICH/BB **108** with data so denoting. Further,

5 MCH/ICH/BB **108**, e.g. the ICH portion is equipped, and initialized to generate an interrupt (e.g. a System Management Interrupt (SMI)), and transfer control to a designed interrupt handler of BIOS **124** in response to the OS write.

As a result, BIOS **124** is able to intervene in the suspend process. More specifically, in various embodiments, BIOS **124** intervenes to set system **100** up
10 to shut off DC power source **132** at the passage of a time period, block **308**. The time period is the application dependent period beyond which drawing on DC power source **132** is no longer desirable, and as described earlier, in some embodiments, may be specified to system **100**.

In various embodiments, BIOS **124** sets system **100** up to shut off DC
15 power source **132** at the passage of a time period, by scheduling RTC to initiate waking system **100** up at the end of the time period. In other embodiments, BIOS **124** sets system **100** up to shut off DC power source **132** at the passage of a time period, by setting a timer, such as timer **146**, to expire at the end of the time period.

20 In various embodiments, BIOS **124** may be further equipped with the ability to save a persistent copy of the then system state in a persistent storage device, such as a hard disk drive. However, this is not an essential aspect of the disclosed embodiments of the present invention. It is the subject matter of the above-identified co-pending U.S. Patent Application, number <to be inserted>.

25 Upon setting up system **100** (and optionally saving a persistent copy of the operational state system **100**), BIOS **124** causes the suspend process to continue (e.g. completing the OS attempted write to the special register).

In various embodiments, the suspend process continues with MCH/ICH/BB 108 turning off the delivery of all normal power within system 100, except for the delivery of standby power to one or more selected elements of system 100, e.g. memory 106, block 310.

5

Figure 4 illustrates one embodiment the relevant operation flow of system 100 to transition system 100 to an active state, in responding to an AC re-presence condition, while operating in a suspended state, including cancellation of a prior system set up to shut off DC power source 132 at a later point in time.

10 Recall from earlier description, for the embodiment, system 100 is in a suspended to memory state 204, more specifically, "suspended to memory with a persistent copy of the system state saved" state 218. However, as described earlier, alternate embodiments may be practiced without the support for intervening in a suspend to memory process, and saving a persistent copy of the
15 operational state of system 100.

As illustrated, for the embodiment, power supply 116 monitors for AC presence or absence and outputs a signal to denote AC presence or absence accordingly, while operating in state 218, block 402. Again, as described earlier, in alternate embodiments, the monitoring and signaling of AC presence or
20 absence at power supply 116 may be performed by another element other than power supply 116. Regardless, the monitoring and signaling continues as long as AC is absent at power supply 116.

However, when AC is re-present at power supply 116, and monitor 130 outputs signal 136 so denoting. For the embodiment, MCH/ICH/BB 108
25 responds to signal 136 as a device wake event, re-enabling delivery of normal power outputs of power supply 116 to elements of system 100, and then transfers control to BIOS 124, block 404. As described earlier, in various

embodiments, the device wake event is processed by the ICH portion of
MCH/ICH/BB 108.

At block 406, BIOS 124 performs various initializations of hardware
elements as appropriate, including in particular, determining the cause of the
5 device wake event. On determining the cause of the device wake event being
AC re-represent, in various embodiments, BIOS 124 further cancels a prior set
up to shut off DC power source 132 at a later point in time.

For an RTC embodiment, BIOS 124 cancels the scheduled wake up with
RTC. For a timer embodiment (regardless of the disposition of the timer), BIOS
10 124 cancels the timer previously set up to automatically shut off DC power
source 132.

Thereafter, BIOS 124 transfers control to a resume vector previously set
up by OS 126 (as part of the suspend to memory process).

At block 408, OS 126 completes the resume process, and system 100
15 continues operation, starting from the previously suspended system state in
memory 106.

As described earlier, alternate RTC embodiments may be practiced
without canceling the scheduled wake up, but ignores, suppresses, overrides or
otherwise renders the waking to shut off DC power source 132 ineffective at the
20 later point in time, as system 100 would have been already awoken. Similarly,
alternate timer embodiments may be practiced without canceling the timer set,
but ignores, suppresses, overrides or otherwise renders the expiration of the
timer to shut off DC power source 132 ineffective at the later point in time.

25 **Figure 5a** illustrates the relevant operational flow of system 100 in
response to the scheduled wake up by RTC, in accordance with one
embodiment. As illustrated, in response to a scheduled wake up by RTC, similar

to the process earlier described for processing AC re-presence as a wake up event, MCH/ICH/BB 108 re-enables normal power delivery within system 100, and then transfers control to BIOS 124 to wake system 100, block 502.

At block 504, BIOS 124 performs various initializations of hardware
5 elements as appropriate, including in particular, determining the cause of the device wake event. On determining the cause of the device wake event being a scheduled wake up with RTC, instead of completing the wake up process and transitioning system 100 from suspended state 218 into an active state 202, BIOS 124 causes DC power source 132 to be shut off. As a result, system 100
10 transitions from suspended state 218 to un-powered state (G3) 206 instead, block 506.

In various embodiments, BIOS 124 effectuates the shut off through the ICH portion of MCH/ICH/BB 108.

15 **Figure 5b** illustrates the relevant operational flow of system 100 in response to the expiration of the timer set as part of the suspend process, in accordance with one embodiment. As illustrated, in response to the expiration of the timer set as part of the suspend process, MCH/ICH/BB 108 or power supply 116 (depends on the embodiment) outputs a signal turning off switch 206, block
20 **512.**

As a result, integral backup DC power 132 is shut off, and prevented from sourcing power for system 100. In turn, system 100 enters un-powered state 206, block 514.

25 Thus, it can be seen from the above description, a method to conserve power, in particular, integral DC backup power, in the absence of AC has been described. As described earlier, the feature is particularly useful in enabling

integral DC backup power to be provided to a computing device in a more cost effective manner. Further, in various implementations, it enables the computing device to be more readily returned to a last known state.

While the present invention has been described in terms of the foregoing
5 embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described. Other embodiments may be practiced with modification and alteration within the spirit and scope of the appended claims. Accordingly, the description is to be regarded as illustrative instead of restrictive.